Midwest Regional Carbon Sequestration Partnership — Development Phase Large-Scale Field Project

Background

The U.S. Department of Energy Regional Carbon Sequestration Partnership (RCSP) Initiative consists of seven partnerships. The purpose of these partnerships is to determine the best regional approaches for permanently storing carbon dioxide (CO_2) in geologic formations. Each RCSP includes stakeholders comprised of state and local agencies, private companies, electric utilities, universities, and nonprofit organizations. These partnerships are the core of a nationwide network helping to establish the most suitable technologies, regulations, and infrastructure needs for carbon storage. The partnerships include more than 400 distinct organizations, spanning 43 states and four Canadian provinces, and are developing the framework needed to validate geologic carbon storage technologies. The RCSPs are unique in that each one is determining which of the numerous geologic carbon storage approaches are best suited for their specific regions of the country and are also identifying regulatory and infrastructure requirements needed for future commercial deployment. The RCSP Initiative is being implemented in three phases, the Characterization Phase, Validation Phase, and Development Phase. In September 2003, the Characterization Phase began with the seven partnerships working to determine the locations of CO_2 sources and to assess suitable locations for CO_2 storage. The Validation Phase (2005–2012) focused on evaluating promising CO_2 storage opportunities through a series of small scale field projects in the seven partnership regions. Finally, the Development Phase (2008-2020+) activities are proceeding and will continue evaluating how CO_2 capture, transportation, injection, and storage can be achieved safely, permanently, and economically at large scales. These field projects are providing tremendous insight regarding injectivity, capacity, and containment of CO_2 in the various geologic formations identified by the partnerships. Results and assessments from these efforts will assist commercialization efforts for future carbon storage projects in North America.

The Midwest Regional Carbon Sequestration Partnership (MRCSP) was established to assess the technical potential, economic viability, and public acceptability of Carbon Capture and Storage (CCS) within a region consisting of nine contiguous states: Indiana, Kentucky, Maryland, Michigan, New Jersey, New York, Ohio, Pennsylvania, and West Virginia. The Battelle Memorial Institute (Battelle) managed effort is comprised of

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Rutgers University
Western Michigan University
West Virginia Geological Survey
Maryland Geological Survey

PROJECT DURATION

Start Date
10/01/2005

End Date
12/31/2019

COST

Total Project Value
$114,878,766

DOE/Non-DOE Share
$87,267,913 / $25,610,853

PROJECT NUMBER

DE-FC26-05NT 42589

a group of nearly 40 organizations from leading universities, state geological surveys, non-governmental organizations and private companies that have been assembled to carry out this research.

Due to its large and diverse economy, the MRCSP region includes a large variety of greenhouse gas sources. While distributed sources, such as agriculture, transportation, and home heating, account for a large portion of CO_2 emissions in the MRCSP region, more than half of CO_2 emissions are linked to stationary sources. In total, approximately 670 million metric tons of CO_2 are emitted each year from these stationary sources. Emissions are highest along the Ohio River Valley and coastlines, where many power plants and industries are located. Electricity generation in the MRCSP region accounts for approximately 80 percent of the region's CO_2 stationary source emissions. The region offers significant potential for storage in deep saline formations (both carbonate and clastic formations), unmineable coal seams, and depleted oil and natural gas fieldsidentified by the partnerships. Results and assessments from these efforts will assist commercialization efforts for future carbon storage projects in North America.

Project Description

Project Summary

MRCSP is performing a large volume injection test of at least 1 million metric tons of CO_2 into geologic formations associated with enhanced oil recovery while continuing to develop a detailed assessment of the region's geologic storage potential through geologic characterization efforts. The MRCSP is accomplishing regional characterization through continued collaboration with geologic research teams from all nine states within the partnership region and is focused on conducting carbon storage capacity estimates through modeling and injection (in addition to evaluating carbon storage permanence in a variety of geologic formations). Research and testing have established many promising geologic units for carbon storage, including deep saline formations, depleted oil and gas reservoirs, organic shale layers, and coalbeds. Geological surveys from the nine MRCSP states assessed the potential for geologic storage, which indicates there is enough resource to permanently store hundreds of years of CO_2 emissions from the region. Current activities to improve the region's storage potential estimate include:

- Continuing characterization and documentation of geological storage systems throughout the region
- Performing petrophysical studies, high resolution geophysical surveys, and sophisticated well log analysis to refine the mapping of carbonate geologic reservoirs
- Assessing carbon storage in and enhanced gas recovery (EGR) from organic shale
- Supporting the broader MRCSP research team in developing and evaluating various regional strategies for implementation of carbon storage technologies
- Uploading geographic information system data to the National Carbon Sequestration Database and Geographic Information System (NATCARB) and National Atlas efforts, as well as focusing on creating high-profile, user-friendly web pages to allow broad knowledge sharing of all projects via multi-media, interactive maps, social media interfaces, and others

- Performing piggy-back drilling to obtain additional regional data by collaborating with oil and gas drillers in the region
- Evaluating the impacts of the changing sources within the MRCSP region on CCS implementation issues
- Continuing to explore for opportunities to expand the knowledge base pertaining to the geologic potential of the MRCSP region by acquiring existing seismic lines, piggybacking on new seismic surveys, and performing additional analyses on existing core samples and other analyses of existing geological data
- Making an initial assessment of the geologic storage capacity and injectivity of the Northern Fairway of Michigan's Niagaran Reef Trend and refine the assessment based on reservoir modeling over the course of the project

MRCSP's large-volume CO_2 injection and storage test is focused on the Niagaran Reef Complex (carbonates) located in Ostego County, in northern Michigan (Figure 1). The site is managed by MRCSP's partner, Core Energy, and is in the vicinity of natural gas processing plants that provide CO_2 for the EOR operations. The information gathered from this effort is being used to assess the CO_2 storage capacity and injectivity of these carbonate formations and understand the applicability of these data to other carbonate formations in other states within the MRCSP region. In addition, new and innovative technologies for tracking the movement of CO_2 within these formations are being implemented and the results used to develop and validate multiphase, multi-process computer models (using software such as GEM) to determine the impact of these operations. The findings and results are being shared through outreach activities and attendance at key industry meetings, MRCSP-hosted events for partners and stakeholders, and through reports, website, brochures, and other documents approved for release to the public.

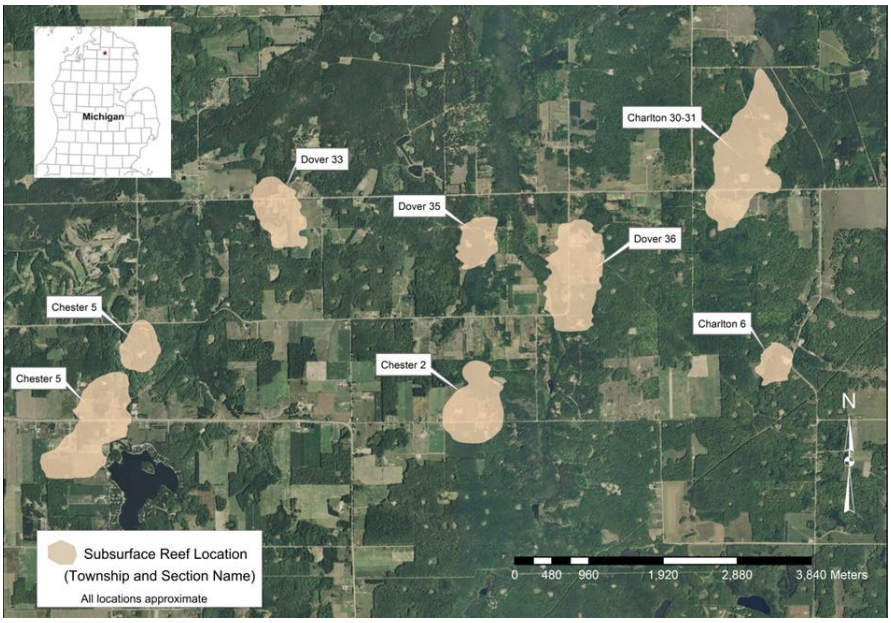

Figure 1 – Identified pinnacle reef locations within the project area in Ostego County, Michigan.

The project is completing tasks related to planning, site characterization, and reservoir modeling. Post-injection monitoring and site closure (or transfer to another entity), as applicable, will also be part of this project. Carbon dioxide injection, storage, and monitoring operations are being carried out for three categories of Niagaran reefs distinguished by different stages in the EOR life-cycle. They are as follows:

- Category 1 Niagaran reefs are late-stage CO_2 EOR reefs that have depleted oil reserves and have undergone primary and secondary oil recovery.
- Category 2 Niagaran reefs are medium stage EOR reefs that have undergone primary oil recovery and are actively undergoing secondary recovery using CO_2.
- Category 3 Niagaran reefs are early-stage EOR reefs that have finished primary oil recovery, but no secondary CO_2 recovery has been undertaken.

Description of Geology

A pinnacle reef is a localized carbonate (usually limestone) structure, which is typically conical in shape and may act as a trap for hydrocarbons in the subsurface. In northern Michigan, these pinnacle reef formations are part of the Northern Fairway of the Niagaran-aged Reef Trend, and were typically formed during the lower Paleozoic period and, though localized in nature, may still be laterally extensive and several hundred feet thick (Figure 2). These pinnacle reef formations are currently undergoing active oil and gas exploration and extraction operations as part of this project, and they represent a significant opportunity for carbon storage and EOR related activities.

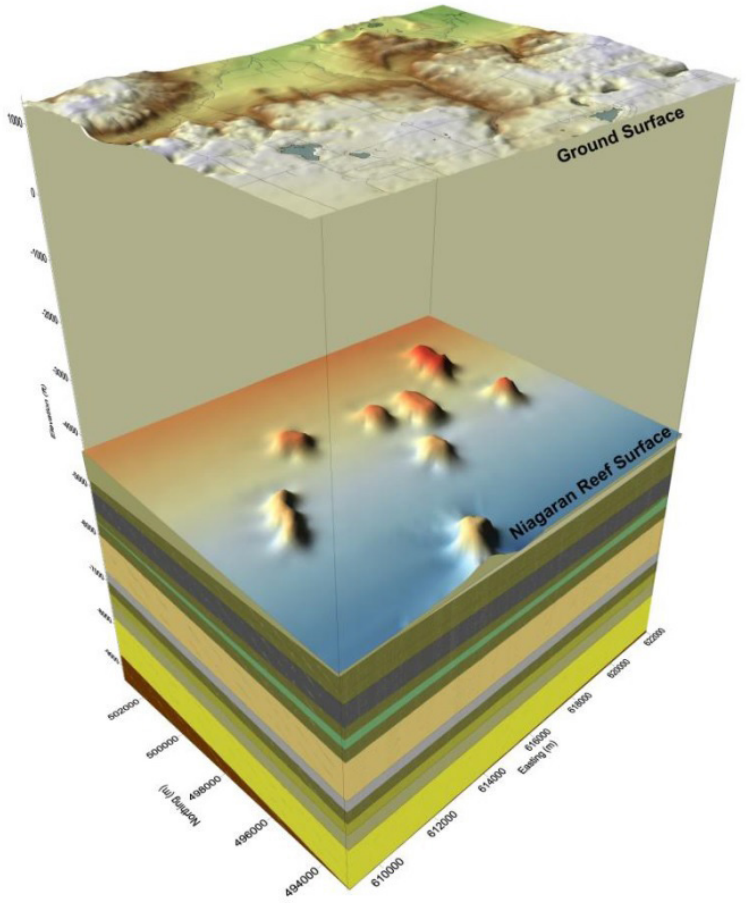

Figure 2 – Depiction of Niagaran Reef surface relative to the ground surface. The raised areas represent the pinnacle reefs that act as traps for oil and gas and provide potential storage for CO_2.

Source of CO_2

MRCSP is purchasing CO_2 from Core CO_2 Services LLC, who operates a large natural gas processing facility located in Chester Township that is in close proximity to the Niagaran reefs under investigation in this project. This gas processing facility produces large quantities of nearly pure CO_2 as a byproduct of natural gas processing for market. Core CO_2 Services has existing infrastructure in place to compress, transport, and otherwise prepare CO_2 for injection.

Injection Operations and EOR Activities

MRCSP is evaluating pinnacle reef formations at three different stages of CO_2-EOR operations: late stage (Category 1), active stage (Category 2), and early stage (Category 3) in northern Michigan for the purpose of large-scale carbon storage. Operations within the late stage and active EOR fields are utilizing existing wells and infrastructure, and supplemental geologic characterization and modeling activities are being conducted. Finally, MRCSP is identifying new opportunities for CO_2-EOR operations within Ostego County, Michigan.

Late Stage EOR Operations

MRCSP is evaluating CO_2 injection potential, assessing CO_2 migration within the subsurface, and working to understand the potential for carbon storage in a carbonate pinnacle reef geologic setting comprising a mature, closed reservoir in the late stages of CO_2-EOR operations. MRCSP defines a late stage CO_2-EOR Niagaran reef as one that has undergone extensive primary and secondary oil recovery and is mostly depleted of oil. Conducting CO_2 injection and monitoring in this setting will provide significant insights into addressing project objectives, which include assessment of injectivity in complex carbonate reef deposits; identification of CO_2 trapping mechanisms in a closed reservoir system; assessment of any final oil recovery from transitional or residual oil zones in a field where CO_2-flooding is nearing completion; evaluation of the transition from EOR to storage of CO_2; assessment of regional commercialization; assessment of new technologies for tracking underground movement of CO_2, brine, and oil; and monitoring options in a closed reservoir with oil, residual oil zone, and water zones.

MRCSP is conducting geological characterization and pre-injection monitoring using appropriate selection of technologies such as borehole seismic, wireline logging, vertical seismic profiling, and microseismic sensors to conduct a baseline assessment of the pinnacle reef. In addition, MRCSP is compiling, reviewing, and analyzing drilling logs, geophysical logs, rock core tests, brine chemistry, formation tests, bottom hole pressure data, and surficial atmospheric conditions. This information is being incorporated into modeling software to supplement characterization operations. After completing characterization and modeling activities, MRCSP began injecting CO_2 into the selected CO_2-EOR reef and implementing a comprehensive monitoring program to ensure that the plume had stabilized. Monitoring includes daily reservoir pressure and temperature monitoring, fluid sampling, pressure testing of the well annulus, yearly cement bond logs, vertical seismic profiles, advanced tracer studies, and additional numerical modeling efforts.

Active EOR Operations

MRCSP is evaluating CO_2 injection potential, assessing CO_2 migration within the subsurface, and determining the potential for carbon storage in a Niagaran reef currently undergoing active CO_2-EOR operations. These reefs have undergone primary oil recovery and are currently undergoing secondary oil recovery using CO_2. MRCSP is monitoring the wells and pipelines to obtain geological and operational data that will be used to validate reservoir simulation models and provide mass balances on the EOR operations to determine the amount of CO_2 retained in the formations. There are currently five active reefs targeted for analysis. This effort includes options for assessing the fraction of CO_2 retained in the target reservoir, upward leakage, and migration pathways. Numerical models of the CO_2 injection system are being calibrated and validated with monitoring data to demonstrate the ability to predict CO_2 movement within the reservoir.

Early Stage EOR Opportunities

In addition, MRCSP is evaluating CO_2 injection potential, assessing CO_2 migration within the subsurface, and working to understand the potential for carbon storage in two newly targeted Niagaran reefs within the project area. These reefs have undergone primary oil recovery but not secondary oil recovery using CO_2. A comprehensive monitoring program is being implemented to evaluate CO_2 movement in the reservoir and various trapping mechanisms that affect CO_2 retention or production. The data generated from evaluating these reefs will provide valuable new information about their geology because new wells will have to be drilled for CO_2-EOR operations and MRCSP will piggyback on the drilling operations to collect extensive core samples and advanced geophysical logs and conduct advanced reservoir injection tests (spinner and isolated injection zone testing).

Goals and Objectives

The primary objective of the DOE's Carbon Storage Program is to develop technologies to safely and permanently store CO_2 and reduce greenhouse gas emissions without adversely affecting energy use or hindering economic growth. The programmatic goals of Carbon Storage research are to (1) develop and validate technologies to ensure 99 percent storage permanence; (2) develop technologies to improve reservoir storage efficiency while ensuring containment effectiveness; (3) support industry's ability to predict CO_2 storage capacity in geologic formations to within 30 percent; and (4) develop best practices manuals for monitoring, verification, accounting, and assessment; site screening, selection, and initial characterization; public outreach, well management activities, and risk analysis and simulation.

The objectives of the MRCSP Development Phase Test are to promote understanding of injectivity, capacity, and assess the feasibility of utilizing and storing CO_2 in geologic formations as well as translate the knowledge gained to develop a better understanding of how carbon storage technologies can best be applied on a regional basis. Specific objectives include:

- Inject one million metric tons of CO_2 into geologic formations, including oil fields at different stages in their life cycles, and translate these results toward regional-volume application
- Determine how much CO_2 is safely retained or produced and recycled with oil recovery—through innovative approaches governing when and how CO_2 is injected into the reefs—and examine how CO_2 migrates through the geologic formation
- Perform reservoir modeling—augmented by hydraulic, geophysical, and system monitoring—to demonstrate the carbon storage process, determine mechanisms that affect permanent carbon storage, and assess regional commercialization potential
- Translate the results of this project to a regional volume by integrating results into NATCARB, participating in technical working groups to develop and document CCS best practices, and communicating results to MRCSP members

Accomplishments

The following accomplishments have been achieved:

- Completed baseline geologic characterization and acquisition of monitoring data from the site. The effort included wireline logging, gravity meter logging, vertical seismic profiling, microseismic monitoring, remote sensing, and reservoir testing.
- Began injection activities into a late-stage EOR within the Niagaran Reef complex. Approximately 1,000 tons per day of CO_2 is being injected.
- Began gathering data at an active stage EOR site within the Niagaran Reef complex. Approximately 110,000 metric tons of CO_2 have been injected from the start of monitoring through June 2013.
- Evaluated CO_2 geologic storage potential in deep saline formations in Drake County, OH and Otsego County, MI using available data.
- Collected advanced wireline logging data from an exploratory well in Wayne County, OH. The data are being used to further characterize potential storage formations in the region.
- Conducted outreach activities in conjunction with these field efforts.
- Conducted regional geologic characterization efforts throughout the MRCSP region as part of the original Phase III activities.

Benefits

- Enhance the knowledge base related to CO_2 injection and storage in carbon pinnacle reef formations for the purpose of EOR operations. The characterization operations set to occur in pinnacle reef reservoirs at various stages of their life-cycle as a petroleum resource will provide vital data on the storage capacity and permanence of CO_2 within these structures. This research effort will also serve to improve the efficiency of carbon storage operations during EOR activities.
- Provide a greater understanding of CO_2 sources and storage opportunities throughout the MRCSP region.
- Provide an assessment of commercial-scale CCS deployment capabilities across the region, and provide valuable data related to CCS operations to several outside sources, including NATCARB.